UNITED STATES OF AMERICA
EASTERN DISTRICT OF MISSOURI
EASTERN DIVISION

AMERICAN AUTOMOBILE INSURANCE COMPANY,)
)
Plaintiff,)
)
vs.) No. 4:11-CV-305 AGF
)
OMEGA FLEX, INC.,)
)
Defendant.)

TRANSCRIPT OF JURY TRIAL EXCERPT
TESTIMONY OF THOMAS W. EAGAR

BEFORE THE HONORABLE AUDREY G. FLEISSIG
UNITED STATES DISTRICT JUDGE

July 9, 2013

APPEARANCES:

For Plaintiff: Mr. Mark E. Utke
Mr. Anthony J. Morrone
COZEN AND O'CONNOR
333 W. Wacker Drive, Suite 1900
Chicago, IL 60606

Mr. Stephen D. Hoyne
STEPHEN D. HOYNE, ATTORNEY AT LAW
P.O. Box 210
St. Louis, MO 63026

For Defendant: Mr. William J. Conroy
Ms. Lynne M. O'Brien
CAMPBELL AND CAMPBELL
1205 Westlakes Drive, Suite 330
Berwyn, PA 19312

Mr. Thomas P. Berra, Jr.
Mr. Oliver H. Thomas
LEWIS RICE
600 Washington Ave., Suite 2500
St. Louis, MO 63101

REPORTED BY: SUSAN R. MORAN, RMR, FCRR
Official Court Reporter
111 South 10th Street
St. Louis, MO 63102
(314) 244-7983

Proceedings recorded by mechanical stenography, produced by computer-aided transcription.

I N D E X

E X H I B I T S

(The following proceedings are an excerpt of the jury trial held in open court on July 9, 2013 beginning at 3:50 p.m.:)

THE COURT: Okay. You may call your next witness.

MR. UTKE: Plaintiff calls Dr. Thomas Eagar.

THOMAS EAGAR,

Having been first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. UTKE:

Q. Good afternoon, sir.

A. Good afternoon.

Q. Please introduce yourself to the jury.

A. My name is Tom Eagar. I'm a professor at MIT in Cambridge, Massachusetts.

Q. And is that the Massachusetts Institute of Technology?

A. Yes, it is.

Q. And what is it that you do at MIT?

A. I'm a Professor of Materials Engineering and Engineering Systems.

Q. How long have you worked there, sir?

A. Thirty-seven years on the faculty, but I spent two years in industry. But before that I was a student there for six years.

Q. And what positions have you held at MIT?

A. I've been head of our manufacturing program. I've been head of the materials processing center. I've been department head of the department of material science and engineering. I've held several chaired professorships. And I teach classes and do research.

Q. And what is your educational background?

A. I got my bachelor's degree from MIT in 1972. And I got my Doctor of Science, which is the same as a Ph.D, but it's an ScD, in 1975.

Q. And about your work history, did you work after obtaining these degrees?

A. When I first graduated, I went to work in 1974 for Bethlehem Steel Corporation in their research laboratories.

Q. Do you serve on any national committees?

A. Yes, I do.

Q. Can you tell us what committees you serve on?

A. Well, I've served -- one of the most recent ones is I serve on the Board of Armor and Armaments for the U.S. Army. That's where they develop the armor for tanks and penetrators, which are basically the missiles they shoot at other people's tanks.

It's also the group that developed all the techniques to defeat the improvised explosive devices. Once this lab was given the charge by the Secretary of the Army to, you know, keep American soldiers from being killed by the

improvised explosive devices, within nine months no more American soldiers have been killed by these devices because of their technology. So I review their technology.

I served on a board for the National Institute of Standards and Technology, which is their manufacturing group. And they look at various standards and measurements and how to make precise measurements. They do calculation on some materials. They have the fire protection program for the U.S. government at that laboratory in Gaithersburg, Maryland.

I've served on review committees for Sandia National Labs, Oak Ridge National Labs, the U.S. Navy, the U.S. Army, Ohio State University. A host of these different things over the years.

Q. Sir, what is the National Research Council?

A. The National Research Council is the research arm of the National Academy of Sciences. The National Academy of Sciences was chartered by President Abraham Lincoln in, I think, 1863 to take the top scientists of the United States and have them to give advice to the U.S. government. So Congress might give a certain amount of money to the National Research Council to try to figure out what the levels of lead in water ought to be. Or I served on a committee that looked at how the U.S. Air Force should spend the $300 million a year that they have to develop better engines and more efficient engines and faster engines for aircraft and

aerospace things.

So the National Research Council is a part of the National Academy of Sciences, which includes the National Academy of Sciences, which is about 3,000 of the top scientists; the National Academy of Engineering, of which I'm a member, which are the 2,000 top engineers in the country; and the Institute of Medicine, which is about the 600 or 1,000 top medical doctors.

Q. Have you done any work for the United States Department of Energy?

A. Yes, I have. The review of Oak Ridge, Sandia, Idaho National Engineering Laboratory, that's all review of Department of Energy laboratories. I also had research money from the Department of Energy in the area of arc physics and welding for about 20 years.

Q. Have you ever worked on submarines for the Navy?

A. Yes. Well, actually indirectly my first research grant as a faculty member in 1977 was for titanium submarines, which we've never built, at least not big ones. The Soviets built one in 1980 called the Alpha sub. If you've ever read Hunt for Red October, they talk about the Alpha sub in there. And I was involved. When the Alpha sub came out, I was intimately involved because I was one of the only non-U.S. Navy researchers that had done work on welding very thick titanium.

Q. Did you do any work on the Star Wars project?

A. Well, I think -- for the Navy, I think you might be thinking -- I did do some work on Star Wars spinoffs. In 1992 as peace was breaking out with the former Soviet Union, there had been the Star Wars stuff under Ronald Reagan in the 1980s, and they developed particle beam weapons. They spent a quarter billion dollars at the U.S. Navy developing particle beam weapons to try to shoot down incoming missiles that might be attacking a cruiser or aircraft carrier.

And so the Navy came to me and said, well, what could we do with this technology since we're not going to use it to fight the Soviet Union anymore? And they wanted to know if they could weld together submarines. And I said, well, you might be able to melt a submarine, but with that much power it's more than you need for welding. And so I worked with them on that.

I worked with them, in 1992 they were building the Seawolf submarine. And they built 18 percent of it and they found cracks in the welds. And so I was brought in to advise the chief engineer of the Navy, the admiral who headed up the engineering of the Navy, about how to fix the problem. And it ended up being about a $2 billion problem for the U.S. Navy. Congress was not happy.

Q. Have you done any work on spacecraft?

A. I have. I worked on the X-33 space plane. Well, we

all know now that the Space Shuttle was decommissioned, but we knew back in 1995 or so that we were going to have to decommission the Space Shuttle, it was going to get too old. And so they -- NASA was developing what they called the X-33 space plane, which was supposed to be a half size version of a new Space Shuttle. And they went to build this thing -- actually the Lockheed Martin Skunk Works in Palmdale, California.

So I got to go out there and see where they built this thing. And they built these liquid hydrogen tanks and manufactured those. And so I had to look at the design of that and things and figure out why it failed. It actually failed in service in Huntsville, Alabama, and they ended up scrapping a $1.3 billion program. But I had to review that program and why the design and everything that went on failed.

Q. In the aftermath of the World Trade Center attacks, did you have any input into the analysis of the tower failures?

A. Well, I was asked about two or three weeks after the event if I would write an article for a metallurgical journal, and I said yes. Because, frankly, I was so tired of hearing incorrect things in the news media about what went on. There were things about the steel melted. Well, anyone who has ever done a fire investigation knows that steel doesn't melt in normal fires. We needed Sir Henry Bessemer

in 1856 to teach us how to melt steel in a normal fire. You can't do it in normal fires.

So I agreed to write an article about why the World Trade Center collapsed. And, in fact, for about ten years, I was the most cited author on the collapse of the World Trade Center. I think I'm now No. 2 or No. 3.

Q. Have you ever testified before the United States Congress?

A. Yes, I have. I was asked, oh, it must be close to ten years ago now, to testify before the Committee on Science and Technology of the U.S. House of Representatives about loss of manufacturing jobs overseas, why had we been losing our competitiveness, why were so many jobs going to Asia. And so I testified before Congress and pointed out, America still has the highest productivity, but it has to do with other factors like exchange rates. You know, people are underselling us because they don't pay their own people very much.

Q. Do you have a background in arc physics?

A. Yes, I do. I've actually -- since about 1977 or '78, I actually have -- I've defined the area of research that I do at university is the physics and chemistry of welding. Well, the physics of welding, most of the welding we do is arc welding. And because of that, I've studied arc physics for over 30 years. And I've written papers on arc physics. And

I teach arc physics in my welding course.

I teach how florescent lights work. I don't see any in here, but anyway -- because a florescent light is a certain type of arc. Lightning is a type of arc as regards to this. I have studied welding arcs essentially for three decades.

Q. And I was going to ask you the distinction and whether you've done any work with low pressure arcs as opposed to hide pressure arcs?

A. Well, the fluorescent light is a low pressure arc. If you've ever broken a fluorescent light bulb, it actually implodes. It goes pop. But it doesn't explode outward, it actually implodes inward because there's a partial vacuum inside. And that's a different type of arc than what we call -- the physicists call a high pressure arc. A high pressure arc is anything at atmospheric pressure. It doesn't have to be any higher pressure than just the air we breathe. But lightning and welding arcs are both what we call high pressure arcs. So essentially everything I've worked on in my research has been high pressure arcs, which lightning is one of those type of things.

Q. Have you published any articles?

A. Yes, I have.

Q. Approximately how many?

A. Over 220 articles right now, plus I have -- I can't

remember if it was 15 or 16 patents.

Q. And are any of those patents in the field of metallurgy or arc physics?

A. Yes. I would say 125 or 150 are metallurgy. Of those I would say 50 of the 200 some are arc physics and/or metallurgy that include arc physics. And I would say the others have to do with manufacturing and design.

Q. Of the articles you've written, are any of them peer reviewed?

A. Actually of the 220, I would say probably 200 of them are peer reviewed. In fact, I've received approximately 10 or 12 awards for best papers. And those are given for peer reviewed articles that are among the best in the scientific literature.

Q. Can you -- for the juror's edification, what is a peer reviewed article?

A. A peer review is the top form of trying to decide what science is the best and should go forward and should -- we should spend the money to publish. There's actually an ad on TV now about everything on the Internet is true, right. Because where did you get that? From the Internet, right. Well, not everything on the Internet is true.

But in a peer reviewed publication, you actually send it to two or three other people who in most cases the reviewers or anonymous, so they are free to say whatever they

want.

Now, I've been a peer reviewer, I've been a chief reviewer, picking the other people to do these reviews. But typically you send them out, and a few weeks later you'll get back a review from a knowledgeable scientist in the area, and they'll say, this paper is acceptable as is, this paper is acceptable with these minor revisions or with these major revisions, or this is such junk science, it's not worth the paper it's written on, so let's not print it on even more paper. So it's a way of quality control in the scientific literature.

Q. Have you previously been qualified in the field of metallurgy and arc physics in state and federal courts?

A. Yes.

MR. UTKE: Your Honor, I submit to the Court that Dr. Eagar is an expert in the field of metallurgy and arc physics.

MR. CONROY: No objection.

THE COURT: All right. He will be qualified as an expert in metallurgy and arc physics.

MR. UTKE: And, Your Honor, I would move to admit Exhibit 109, 110, 36-B, and 35-B into evidence.

MR. CONROY: No objection.

THE COURT: All right. Exhibits 109, 110, 36-B, and 35-B will be admitted.

BY MR. UTKE:
Q. Sir, let me show you two items that are labeled Exhibit 35-B and 36-B, and I have some questions for you.
A. Okay.
Q. First, are you able to identify what 35-B is?
A. 35-B is a piece of black iron pipe. It's actually called a nipple because it's threaded on both ends. You can buy this at Home Depot.
Q. And what is the -- from a metallurgical standpoint, how thick is the steel on the black iron pipe?
A. For this size black iron pipe, it's just over a tenth of an inch, it's about .11 inch for this size.
Q. And what type of steel is it?
A. It's what we call low carbon steel. It's the same type of steel composition-wise as the sheet metal in the automobile that you drive basically.
Q. And what is the melting temperature for that steel?
A. This in Fahrenheit is about 2,500 degrees Fahrenheit.
Q. Has that steel been used in applications for the transportation of gas?
A. Yes, for about a hundred years or so.
Q. And that would be residential and commercial?
A. Yes.
Q. Now, the other item in your hand, 36-B.
A. Wait a second, I thought we were on 36-B.

Q. Okay. I'm looking at the CSST.

A. 36-B is the black iron pipe, if I misspoke. 35-B is TracPipe, it actually says on the yellow, but I can also tell because of the shape of the convolutions. They have -- there are various manufacturers of CSST, but Omega Flex's design of the convolutions is asymmetric, it's not a nice symmetric wave, it's actually kind of what we call a saw tooth type of wave.

MR. CONROY: Objection, Judge, to the way he characterized it.

THE COURT: I'm going to overrule that.

BY MR. UTKE:

Q. Sir, have you examined a TracPipe in a laboratory?

A. Yes, I have, a number of times.

Q. Have you determined the wall thickness of TracPipe?

A. Yes, I've measured it myself.

Q. What is the measurement of TracPipe?

A. I typically measure it at about .011 of an inch, almost exactly 10 percent of the thickness of the black iron pipe.

Q. Are you able to equate that --

A. The manufacturers say it's .010 but when you measure something that's already bent and everything, I get about .011.

Q. Are you able to equate that into a thickness that the jurors would be able to have a conception on?

A. It's about four sheets of paper. I think you may have heard that in the openings or something.

Q. Well, now turning to the black iron pipe, in terms of the thickness of that carbon steel, how thick is black iron pipe?

A. It's about 40 sheets of paper, it's about ten times thicker.

Q. And from a metallurgical standpoint, what does thickness of steel have to do with the ability of the metal to sustain energy from electricity?

A. Whether it's energy from electricity or anything else, the greater the thickness, the more energy it takes to heat it and melt it, okay. That comes straight out of thermodynamics. The energy to melt it is proportional to the increase in thickness. If I have doubled the thickness, it takes double the energy.

What's important here is not just the energy to melt it but how long it takes to melt it. How long does it take for heat to penetrate through the thickness? And that gets into what we call the second law of heat conduction. And that says that the thicker something is, it takes the square of the thickness. So if something is twice as thick, it takes four times as long to heat it through. You square the two and get four, and it takes four times as long.

So if I'm cooking a hot dog in the oven, I might be

able to heat that up in three or four minutes to where it would be hot enough and it's not a cold dog. Okay. If I have a roast beef, it might take three or four hours because it's so much thicker, and the heat has to penetrate in. In fact, cooking of a roast beef was one of the problems I got as an undergraduate in my heat transfer class, sort of a classic problem to give students how much longer does it take to cook a roast beef if it's bigger. Okay.

Q. And, sir, are you familiar with the term "coulomb"?

A. Coulomb is -- yes, I am.

Q. Tell the jury what a coulomb is.

A. Well, it's named coulomb after a French electrical scientist of the 19th Century. And a coulomb is a measure of the number of electrons. Okay. More people might have heard from high school physics or chemistry the term "ampere." Ampere -- when you hear about a 20 amp circuit breaker, that's a 20 ampere circuit breaker. A coulomb -- or an ampere is a coulomb per second. So if I had 20 coulombs coming out of that wall plug in one second, that would be 20 amperes, it would be 20 coulombs. If it was coming out 20 coulombs over two seconds, it would be 10 amperes.

So it's -- a coulomb is -- or an ampere is the number of electrons times the amount of time that it takes to have that flow. In fact, sometimes we talk about electron flow in terms of an analogy is water flow, and we talk about

water flowing through pipes and how fast it goes and stuff. And you can think about that same analogy for current flow in electric arc in terms of lightning is very fast. It occurs in one or about ten millionths or ten to a hundred millionths of a second. Okay. Whereas your circuit breaker, that trips about a hundred to a thousand times slower. It's a mechanical function. It can't go as fast as lightning. Only lightning goes as fast as lightning. It's a different process.

Q. Is lightning measured in terms of coulombs for its strength?

A. It is. But -- and some people who might be electrical engineers might say, well, why is that? It turns out in an atmospheric pressure arc, even though lightning may be millions of volts when it goes from the sky to the earth, when it actually gets down to the surface of the metal, the energy transferred into the metal is only about ten volts times the number of electrons. That's actually something I teach in my course. It comes out of the arc physics.

And so we can talk about just the number of coulombs, but if you wanted to know the exact amount of energy, you would multiply it by ten volts to get it in watts. But the lightning physics people like to talk about coulombs rather than watts.

Q. Now, referring back to the piece of TracPipe that's in

front of you.
A. Right.
Q. For metal of this thickness, what is the -- how many coulombs does it take to penetrate that stainless steel?
A. Well, there was an engineer at General Electric in 1942 who tested material of exactly this thickness, .010 of an inch think. He made a sphere, put it on top of the Empire State Building, and, you know, measured lightning bolts that hit the top of the Empire State Building. And then he measured the size of the volts. And he came up with a correlation. And for the size holes -- can I jump all the way to the Kostecki holes, is that okay?
Q. Certainly.
A. And this will, I think, short-circuit it. 2.4 coulombs for each hole. So 4.8 coulombs total to form those two holes. And that's based on the correlation that this guy at General Electric did in 1942. And it works pretty well. We've checked it a number of times on this type of material.
Q. And, sir, the same question for the thickness of the steel on the black iron pipe that's in front of you. Is there a measure of energy that it would take to penetrate that steel?
A. You can still use the same coulombs, yes. And, in fact, I know of one test where we were unable to penetrate it at 267 coulombs. In fact, I can tell you based on the

testing that's been done, it takes 2,500 times as much energy and you still haven't penetrated the black iron pipe, as it does to penetrate the CSST. I've estimated the difference in penetration energy is about 5,000 times. It takes 5,000 times as much energy to penetrate this thing that's ten times thicker.

MR. CONROY: Judge, I --

THE COURT: Mr. Utke, I'm going to ask you to start asking this witness more direct questions and let him answer because --

MR. UTKE: I'll guide his testimony, sure.

MR. CONROY: And just one second, please. Some of the comments we're hearing, Judge, is going over the line of what we had discussed before in terms of these comparisons. He has given us dimensions, which he was free to do, but now we're getting into certain comparisons that might be over the line.

THE COURT: And I agree with that.

MR. CONROY: And I would ask to the extent he's making those comparisons, those answers be stricken from the record.

THE COURT: I will, in fact, strike the last comments from the record. And I'm going to direct the jury to disregard those last few comparison comments.

BY MR. UTKE:
Q. Sir, the individual that you spoke about that conducted this testing in the 1940s, was that a gentleman named Hagenguth?
A. Yes.
Q. And based on his testing was the scientific community given information that would allow them to calculate the amount of energy that it takes to penetrate different metals?
A. Yes, he has a little formula that says the area of the hole in square millimeters is 2.9 times the coulombs. Let's see -- yeah, the area -- I'm sorry, the area in square millimeters divided by 2.9 is the amount of coulombs.
Q. And that equation has been relied upon in the scientific community?
A. Yes.
Q. For how long?
A. About 70 years.
Q. And is that something that metallurgists have relied upon as the backbone of metallurgy or science?
A. Yes, metallurgists who also study lightning, such as people in the aircraft industry, they use that -- they go to lightning test centers and they test aircraft wings and things like that to see how much energy it takes to perforate the hole in the wing because that's your fuel tank, and you don't want to have a hole in your fuel tank when you're way

up there.
Q. Now, in this case did you examine the holes in the CSST at the Kostecki home?
A. Yes, I did.
Q. And in front of you is Exhibit 31, which is the pieces of CSST retained from the home.
A. Yes.
Q. Can you tell the jury what type of testing was performed on these pieces?
A. Well, first it came as a piece of longer CSST, and they cut it to a shorter length, which you can see here. And then they sliced that in two so you could see the inside and the outside. And then they looked at it in both a stereo microscope and a scanning electron microscope and took pictures.
Q. Sir, I'm going to show you a microscopic view. Is that visible to you?
A. Yes.
Q. And it came up on the screens?
A. Yes.
Q. Sir, can you tell the jury what it is they are looking at now?
A. These are the two holes that are in Exhibit 31 in a higher magnification, in a stereo microscope.
Q. And from a metallurgist's point of view, can you tell

the jury why it is there's two holes in the CSST as opposed to one hole?
A. Yes, I can.
Q. And what's the reason for that?
A. There were two arc strikes.
Q. What is an arc strike produced from?
A. It can be lightning or it can be something else, but in this case you don't get two arc strikes from a household current, you get two arc strikes from a lightning bolt that has more than one stroke. Any -- well, most or a large fraction of lightning strokes are not a single stroke, they can be up to 10 or 11 strokes. Some of them are a single stroke, but some of them might be two, three, four, or five strokes.

If you see lightning flicker, you're actually seeing the individual strokes superimposed on each other. They are about a tenth of a second apart, and so your eyes can sort of make out the difference. But because of the bright light and they are still pretty close together, it's sort of like when you're watching that video screen, you're actually watching something that's refreshed 30 times a second. The lightning in a sense, the strokes are about ten times a second. And so you actually can see lightning flicker sometimes. And when you're seeing lightning flicker, you're actually seeing a series of arc strikes.

Q. And so it would be two in a row or a series of arc strikes that caused repetitive holes?
A. Right.
Q. Now, from a metallurgical standpoint, looking at Exhibit 109, what is it about this photograph that is significant to you in the field of metallurgy?
A. At a metallurgist I look at these holes and I say, well, this had to be a very rapid process because there's not a lot of melted metal up around the edge. If I took a welding torch or if I just shorted something out from the household current, I would get big -- I say big -- at this magnification I would get blobs of metal held by surface tension around that edge.
Here I see the molten metal, but it's just a thin little bead. And there's some other photographs you can see later where the edges of the hole are almost square. And if you go through the heat flow calculation, you find that that could only be from a lightning strike.
Q. Can you describe to the jury what that heat -- what's the heat flow calculation?
A. It's called Fourier -- a French mathematician -- Fourier's second law of heat conjunction, and it describes heat flow through what we call transient heat flow. Heat flow, if I start with something cold and I put a heat source on the surface, how fast will that heat diffuse into the

surface.

The example I like to give of heat diffusing to the surface is if you have a candle and you run your finger through it quickly, you don't burn your hand or your finger. If you do it slowly, there's time for the flame to transfer heat into your skin, and you'll burn yourself if you give it enough time.

This hole was heated so rapidly that I didn't have time for the metal to bunch up and flow by surface tension. And that tells me this occurred, this -- these holes were formed in less than one millisecond.

Q. And with that in mind, if you were looking at a hole created by household electric current, what would you expect to see?

A. If it's household electric current, I will see not small little beads of melted metal around the edge here, I would see bigger beads, maybe three or four or five times bigger, because the melted metal has time to suck up and form this -- by surface tension this ring of melted metal. That's because the wall plug -- and I keep on pointing over here, there's a wall outlet over here. The circuit breaker takes about 10 milliseconds to cut the current. And so if this was a ten millisecond hole, I'd have much larger rings of melted metal around the edge of this hole.

This hole was produced by lightning -- these holes

were produced by lightning.
Q. And, sir, the Fourier heat transfer equation that you referenced, how long has that been in the field of science?
A. I think since the 1840s or so.
Q. So certainly something that's been available for lifetimes?
A. More than my lifetime, okay. More than my father's lifetime, and more than my grandfather's lifetime.
Q. Now, from a metallurgical standpoint, viewing 109, Exhibit 109, what is it about the metal that allowed these perforations to happen?
A. Well, in this case it's just too thin. I mean, you can see the small --
MR. CONROY: Judge, excuse me, I object to what he just said, and move to strike the answer "too thin." It's characterizing it and goes to design.
THE COURT: I'm going to overrule that objection. Go ahead. People do have to use English. Go ahead.
BY MR. UTKE:
Q. And, sir, when you say that it's "too thin," can you tell me from a metallurgical standpoint what it is about the metal, and can you quantify why it is too thin to handle this type of electrical charge?
A. In order to perforate or get the heat to go through something four sheets of paper thick, you can go through

Fourier's equation and you can find that it takes about a tenth of a second to melt all the way through. And that's separate of any force of blowing the metal out of there. If this was -- well, anyway, we could talk about that.

Why don't you ask the next question. They don't want me to expound.

Q. In terms of the energy dissipated from lightning, what's the average strike in the scientific community?

A. It's three to five coulombs. And it only takes a tenth of a coulomb to penetrate this stuff.

Q. And at any time did you make a determination or conduct research into the amount of energy that it took to create these holes at the Kostecki home?

A. Yes, I did.

Q. And how much energy was that?

A. Well, you can calculate it from Hagenguth, but we've also done experiments in the laboratory. But it's on the order -- well, Hagenguth, the calculation says 2.4 coulombs for each one. I formed similar sized holes with three coulombs in the laboratory.

Q. And, sir, now I'm going to ask you to -- and hopefully the technology works with us. Let's look at 91. Sir, as background, did you also conduct laboratory testing under a scanning electron microscope?

A. I didn't. This came from Dr. Kytomaa's lab, but one of

my engineers was there when they took the pictures, so, yes, I'm familiar with these pictures. I reviewed them after the testing.

Q. Is that typical for a scientist to conduct this type of testing and then share the material amongst each other?

A. Yes.

Q. So the same material you're relying upon is the same scanning electron microscope images that Dr. Kytomaa would be relying on?

A. Yes, as part of his protocol too.

Q. Now, can you describe to the jury what we're looking at in --

MR. UTKE: And I believe we've already moved this into evidence. I would move 91, 92, 93.

MR. CONROY: No objection.

MR. UTKE: Thank you.

A. This is the inside --

THE COURT: Okay. Just a second. 91, 92, and 93 will be admitted.

MR. UTKE: And these are all scanning electron microscope images.

A. So if I go to Exhibit 31, remember, we cut this thing in two so we could look at the inside surface. You're looking at the inside surface in the scanning electron microscope. And the scanning electron microscope is just a

$300,000 TV system for looking at things. It operates on the same principle as the old tube TVs, but it's got a lot of bells and whistles that you don't have on your tube TV.

Q. From a more technical standpoint, can you describe how it is that this electron microscope works?

A. Well, you take a beam of electrons at about 20,000 volts, and you scan it across the surface. That's not the technology of these flat panel TVs. In the old days I could talk about TVs as the old tube. We don't have any anymore, the old cathode ray tubes. And the cathode ray was the beam of electrons, and they would scan across the surface. We call it the raster scan. You scan across the top, you come down one, scan across that, come down one, scan across. And you get like 640 lines per second. Okay. You actually get refresh rates -- well, we don't have to go into how the displays work.

But anyway, basically we scan with the electron beam, and you collect the electrons that bounce off the surface and you can make an image like this. And if you've ever seen bug's eyes, that's the machine that takes the pictures of the bug's eyes magnified by a lot.

Q. And, sir, again, 91-A now, and with the Court's indulgence because we don't have the ability to write on the screens with the technology being altered, I have a blowup that I'm going to ask you to come forward and mark.

THE WITNESS: Can I go down?

THE COURT: You may.

Q. Dr. Eagar, can you describe to the jury specifically what features from a metallurgical standpoint provide you with information to lead to your opinion that this was caused by lightning energy?

A. So this is the inside, and we know that the arc came from the outside. Whether it was household current or lightning, it came from the outside. It turns out there are electromagnetic forces, which we call plasma jets, in that arc, whether it's a welding arc, a short circuit from a household current or a lightning arc, that create a force that blows the metal aside. And what you're seeing here is the metal being blown through the hole and spattered up against the walls on the inside. That's what these little beads and drops are over here.

Q. And, sir, can you circle and point an arrow to some of those spherical shapes?

A. Okay. Here's one. Here's a series right here. Little spherical drops. And we know because they are spherical, they were liquid. Surface tension caused themed to form spheres.

Here we see something that's very flat, and that's different. But that's a bigger blob of metal that came through but just got splatted against the surface and spread

out as flat.

Q. Is this a violent force when it happens?

A. It's a very violent force. And, in fact, that tells me -- I think we've got some other pictures -- but this tells me that this had to be the force of lightning because the force goes as the square of the current. The current out of your wall plug, if you have a short circuit might be 300 amps. You square 300 and you get about 10,000 or about 100,000.

If the lightning is 5,000 amps, you get 25 million. So you compare 25 million to 10,000 or 100,000, there's 25 times more force causing small drops and splatter in a lightning arc than there is in a household current arc.

And, in fact, we see these metallurgical features that tell us distinctly that this is a lightning arc that formed this hole.

Q. Are these the type principles that metallurgists rely on when they look at metal surfaces?

A. Welding metallurgists, people who know arc physics. I wouldn't say every metallurgist knows arc physics. But if you know both of them, which is what I've been doing 35 years, yes, you rely on this.

Q. And what features would you expect to see if this hole was caused by household current arcing?

A. Well, actually this is a good picture because you see

up here this little bulbus thing.
Q. Can you please draw an arrow to it?
A. Actually I'd rather circle it. Is that all right?
Q. Sure.
A. So we don't have arrows and arrows. This just died.
Q. I think it might be the surface.
A. So this right here, that is molten metal too. You can actually see the little rings where it solidified and left little waves behind as it was solidifying.
Q. Hold that thought. I'm going to get --
MR. CONROY: I've got a marker. Try blue.
MR. UTKE: Sure. Thank you.
Q. If you could circle that so we can highlight it better.
A. Okay. (Indicating.) This -- if this had been a wall plug type of short circuit, you would have that size thing all the way around or maybe 80 percent of the way around. This is liquid metal that did flow and bunch up before it finally solidified. But the rest of this has almost no liquid metal, had some liquid metal, but remember, it's much smaller. This took something on the order because of its size, something on the order of 10 or 20 or 30 milliseconds to solidify. This edge took less than a millisecond. That comes out of Fourier's second law of heat conduction.
Q. Sir, let me show you another exhibit. This is marked as 91-B. Sir, now can you define to the jury first what they

are looking at?
A. Well, first of all, I believe this little hump down here is the top side. This the top side. This is the outside. The arc came in this direction. It was blowing metal through this hole when it melted it.
Q. How do you know that from a metallurgist standpoint?
A. Well, I know that the force of the arc will blow the metal. That's how a welder welds overhead. The force of that plasma jet causes the drops to go up against gravity. So even for shorter time arcs, like welding arcs or what you get out of your household current, you can actually blow metal. Because you don't blow it as hard as you do with lightning, because lightning is a hundred times faster, and the pressures are -- what did I calculate before, 25 times or 250 times greater. 25 million versus 100,000.
Q. Are there any other metallurgical features visible to the jury that lead you to your conclusion that this was caused by lightning?
A. Well, we have somewhat sharp edges. I said you'd have a big bunched up thing. If you have a sharp edge here, you can calculate how long that thing will last. If you've ever had problems with your gas grill at home and you get all this poof, all of a sudden it lights, and you singe the hair off your hand, the back of your hand, well, you can do that without burning your skin because those little hairs are so

thin that they can be completely burned in a fraction of a second. Whereas it takes longer times to heat up your whole thick hand. Just like your hand is the roast beef. But anyway --

Q. Sir, let me ask you to just circle the feature on 91-B that shows the sharp edge on the interior of the pipe.

A. Well, you can see it all along here, but this is one area. I could circle almost everywhere around here. Not right here where I had that little bulbus thing, but there's some other photos.

Q. This is 91-C, as in Charlie.

A. And this is also on the outside. Here we actually have the bulbus thing we saw on the inside. Here's one on the outside.

Q. Can you circle those?

A. I can circle those. But the rest of this has got relatively small corners. And if you calculate those corners, I've done it a number of times, those corners would have been melted off and turned into circles if they had lasted for more than a millisecond.

That's why I know this hole from the splatter, from the square inches, from the spatter, from the fact there's two holes right next to each other, all four of those things tell me this is a lightning hole; this is not a household current hole.

Q. Sir, you can go back to the witness stand, I'll have some more questions for you.

Dr. Eagar, you just mentioned the term "spatter," and provided indication as to what a spatter looks like. Let me show you another --

A. Right.

Q. Can you describe to the jury what they are looking at? And I'll represent to you this is Exhibit 110.

A. So this is from Exhibit 31, but from the other side on the inside. So we sectioned it in two. And the side that didn't have the holes, actually when this force of the arc blew the metal through, some of it splatted back on the back side. And so somewhere here on the back side, at 65 times magnification you can see how the molten steel hit the surface with enough force to just be a flat pancake.

Q. That was my next question. Was this taken with a scanning electron microscope or is this a stereo microscope or is it some other type of --

A. It's a scanning electron microscope. And the other thing that's important in this is some of those beads are very small. You can see them, the stringers stringing out, but there's even smaller beads in between. If you look straight at nine o'clock going across there, you'll see some very small beads. You can't get beads that small unless you're blowing in a very strong wind plasma jet. If you had

household current type of winds, you couldn't get beads this small, not this many of them. The winds just aren't strong enough to break up the liquid jet into things this small.
Q. And, sir, the next question I have for you is, are you able to describe to the jury the difference between grounding and bonding?
A. Yes.
Q. Please describe it.
A. Okay. And let me -- I'm going to give you a definition, but these two terms sometimes are used synonymously, okay. But grounding, if you're trying to use them in a different sense, and many times people do, grounding is getting the electrons into the earth. And bonding is just if I got two pieces of metal, connecting them electrically, not necessarily getting the electrons into earth, but getting them electrically connected so they have the electrical potential, there's no big voltage between the two of them because they are electrically connected. They can be on the top of this building, but they don't get to earth. So grounding, think of ground, earth. In fact, the British call it earthing. Okay. Grounding is earthing, getting the electrons into the ground. And bonding is just connecting the metal parts together so that they all have the same potential.
I worked with Learjet once on bonding problems.

They make 10,000 measurements on a Learjet; bonding measurements, not grounding. You can't get the electrons from the plane up in the air to the ground, to the earth, but you do have to bond it.
Q. Dr. Eagar, let me give you more guided testimony. Are you able to define to the jury what a point bond is?
A. A point bond is just making a single location bond as opposed to an area bond where you put two things together like sheets of paper to get the things in contact with one another.
Q. Now, the next term is multi-point bond.
A. Multi-point bond is, okay, you can put it together sort of like the red squares on a chess board. And so you get not an area bond, but a bunch of points, discrete points, and it's somewhere half between an area bond and a point bond, okay.
Q. And the last term is equipotential bonding. What does that mean?
A. Equipotential bonding is just the bonding to make them an equipotential, same voltage. Okay. Equipotential means they are the same voltage.
Q. And are you familiar with the TracPipe Design and Installation Guide?
A. Yes.
Q. Are you familiar with the methods that Omega Flex

prescribes for the installation of its product?
A. Yes, generally.
Q. And what type of bonding does Omega Flex believe is required by their installation guide?
A. They talk about equipotential bonding. The NFPA uses potential equalization. It's the same thing.
Q. Have you done any calculations with respect to bonding as it relates to metal, the thickness of TracPipe, and its ability to withstand electrical charge?
A. Yes, I have.
Q. And can you describe to the jury what -- first of the all, what these equations consisted of, and then lead us through to what your results were.
A. Well, the resistance to ground, to the earth -- the soil is not necessarily a very good conductor. It's not bad, but it's not as good as metal. And if you stick a piece of metal into the earth, you might not resistances not of what we call milliohms. Your toaster oven might be two or three ohms. Those little hot coils that heat up red in your toaster oven, they might be two or three ohms. If I'm bonding on an aircraft, I want ten milliohms is the spec, 1/100 of an ohm.

When I stick a steel rod or a copper rod into the ground to do a lightning protection system, I might be happy with 25 ohms, okay. It's not as low of resistance as your

toaster oven. What happens is as that current is going from the lightning in your house to go through that ground of 25 ohms, if I've got 10,000 amps or 5,000 amps -- well, I'll do 10,000, it's easier to multiply -- by 25 volts, I've got 250,000 volts. That's enough to start arcs all through your home. You can have six-inch arcs between pieces of metals in your home.

And that's what happens in a lightning strike, potentially you can have hundreds of thousands of volts if the things aren't equipotentially bonded. But we also have to remember how fast lightning is. How close do those point bonds have to be to make it equipotential in the time we have available of a lightning strike?

Q. And were you able to do a calculation to determine how far bonding points would have to be on TracPipe to make it enhance its ability?

A. To keep the voltages down so I don't get flashover, these arcs, through different parts of the house, on TracPipe you'd have to be about 10 feet between your area bonding points at the speed of lightning. If you're talking about protecting someone from getting electrocuted at 60 hertz, which is 100 times slower, you could be a thousand feet away from your ground.

So you can have a single point bond to protect people from electrocution in your house. But if you want to

protect your pipe from perforation, you've got to have bonds every 10 feet.

Q. And to have a bond every 10 feet, would that require you have to an AutoFlare joint, as TracPipe refers to it, or a connection point every 10 feet?

A. If you follow what was in the D&I guide that Mr. Juergens was being asked about, yes.

Q. And what is bonding material constructed of in terms of metallurgy?

A. The bonding material is big brass rings, okay. The AutoFlare fittings, those are big heavy brass rings. And one of the reasons that you need to bond to that is because of the resistance of that connection. That clamp connection, that has resistance. That might be one ohm. If you did one ohm on the corrugated stainless steel and you had that much energy, you'd blow a hole where you bonded it just because the current going through the ground. That doesn't do you any good. You have to bond to something that has some thickness to it, otherwise you're just going to blow a hole in what you're bonding to.

Q. Is that the same concept that we talked about earlier, that a thicker metal is required to sustain this type of energy?

A. To carry the heat away. It's the same thing, you know, you've got to have enough what we call thermal mass, enough

metal to suck up the heat without causing it to melt. Something thin is much easier to melt. It's like singeing the hair on your hand. If something is thin, you can burn it more easily, you can melt it more easily.

Q. So bonding every 10 feet, if one of the advantages of TracPipe is the lack of joints, would that add joints to the TracPipe?

A. Yes.

MR. CONROY: Excuse me, Judge, now he's back to making comparisons again, which we discussed earlier.

MR. UTKE: This is bonding.

THE COURT: I understand, but what is this witness's expertise in whether that would or would not cause joints?

MR. UTKE: It's mandatory in their installation guide that you have a joint --

THE COURT: Obviously if it's straight, it's not going to cause joints, is it?

MR. UTKE: Your Honor, I believe the -- and I can lay the foundation with the witness, the Design and Installation Guide requires that you bond to a joint. You can't bond to the pipe. So if you have to have a bond every 10 feet, that means you have to have a joint every 10 feet. And that's the concept.

THE COURT: All right.

BY MR. UTKE:
Q. And, Dr. Eagar, is that consistent with your testimony?
A. Yes. What you just said?
Q. Yes.
A. Yes.
Q. I don't want to be testifying.
A. Right. But, yes, that's consistent. The D&I guide requires that you bond to something like black iron pipe or one of their brass fittings, something that has some thickness to it.
Q. Now, getting back to the failure mode of TracPipe when exposed to energy from lightning --
MR. CONROY: Excuse me, Judge, again, he's talking about the failure mode. This is the design issue --
THE COURT: I will not allow it, Mr. Utke.
MR. CONROY: And I don't want to keep objecting, but I keep hearing this.
MR. UTKE: I can rephrase it.
THE COURT: You must rephrase it.
MR. UTKE: Certainly.
BY MR. UTKE:
Q. From a metallurgical standpoint, when the TracPipe at the Kostecki home was breached, what was the piping carrying?
A. Natural -- well, propane in this case. Gas.
Q. Do you have an opinion in this case as to what the

first fuel ignited was?
A. Yes.
Q. And what was that?
A. Propane.
Q. And how would the propane ignite passing through the holes that were made in the TracPipe?
A. You have to get mixing of the air with the fuel in order to get a flammable mixture. Now, it turns out if you actually do -- if you instantly -- by "instantly" I mean within a millisecond or less -- form a hole in this stuff, the gas starts out at zero velocity when it's just sitting there in the pipe, and it's starting to leak out as a jet. And that jet might be going -- well, it might be going several tens of feet per second, okay. But it starts out at zero. And when it starts out at zero, that means that what we called the sheer between the steel and the air, which are basically not moving around, you don't have a fan blowing on it, and the jet that's starting to emerge, will have a lot of sheer. And when we have a lot of sheer in the area of fluid flow, we have what we call turbulence, and the air and the steel mix.
And Dr. Kytomaa produced some photographs that show exactly that. You don't get a fully developed jet until 15 or 20 milliseconds in his photos. But that first one or two milliseconds, it's turbulent mixed material that can ignite

as soon as it comes out. And we've done videos that show that it ignites within a millisecond.

Q. Okay. And, sir, that leads to my next question that relates to this gas jet that is coming out of the CSST. As it was placed in the Kostecki home, was there any features of the Kostecki home that allowed for such mixing?

A. Yes. I mean, that's just -- you start from zero velocity. Like your car is parked and it starts at zero. It doesn't go to 60 miles an hour immediately, it has to go through 10 miles an hour and 5 miles an hour and everything. But at that exit point, you have -- you have so much sheer in the gas between the stagnant air and the jet forming that you get immediate mixing. And you can see that on Dr. Kytomaa's photographs, Schleiren photographs.

Q. And have you conducted any experiments to simulate a confined space such as the Kostecki home and the mixing that would take place with the gas --

THE WITNESS: Maybe it's the video repairman.

THE COURT: No. Don't know.

Q. Sir, have you conducted any laboratory experiments to simulate the --

THE COURT: Can you come on up.

(The following proceedings were held at the bench and outside the hearing of the jury:)

THE COURT: If you're going to talk about simulating

the confined space in the Kostecki home, you have walked over the line that we talked about. Now, unless you are going to establish --

MR. UTKE: I'm not going to --

THE COURT: But that's what you just said, to simulate the conditions of the Kostecki home. I am not aware that you have laid any foundation that any test he ran simulated the conditions of the Kostecki home. If you want to talk in more generic terms about how being in a confined space might impact that, I'll allow it. But you keep talking about the Kostecki home, and I'm going to throw out this guy's testimony.

MR. UTKE: I understand.

THE COURT: All right.

(The following proceedings continued within the hearing of the jury:)

BY MR. UTKE:

Q. Dr. Eagar, have you conducted any type of laboratory experiment on confined space as it affects the flow of gas?

A. Yes.

Q. And what were you able to determine with respect to the ability of the gas to maintain ignition?

A. If -- I have to compare it between confined jets and unconfined jets, okay. That's the experiment I did. So we took a piece of CSST, we took a copper wire, we arced to it

just with household current.
Q. Doctor, let me slow you down because I want to make sure that I direct your testimony on this issue, because we're on a very fine line of information here.
MR. CONROY: Please -- just a second, please. I thought he was to discuss the general principles, not to talk about specific tests, which the witness is starting to do now. I would move to strike the answer he just gave talking about a wire going onto the CSST -- the TracPipe, Judge.
THE COURT: Let's take this one at a time. Let's take this one step at a time, all right.
MR. UTKE: Sure.
BY MR. UTKE:
Q. Sir, in terms of the mixing of gases, have you conducted any kind of experiment to demonstrate that when gas is mixed, they sustain ignition?
A. Yes.
Q. Are you familiar with the term "hot surface ignition"?
A. Yes.
Q. Is that a scientific concept that is used in every home?
A. Well, not every home, but homes that have gas appliances, we often use hot surface ignitors. They sell a couple hundred thousand a year.
Q. And can you describe for the jury how it is that a hot

surface ignition works?
A. Okay. Well, I can tell you about my furnace at home. I have a gas furnace at home and it has a hot surface ignitor. In the old days we used to have pilot lights, but pilot lights wasted gas. The pilot light was on all the time. The pilot light could go out. And if you didn't know how to restart it, you had to call in the repairman.
About 20 years ago they developed these ceramic materials that would conduct electricity, and you could just turn the power on, put the electricity through them, and they would glow red hot, above 1,800 degrees Fahrenheit.
And it turns out that's enough temperature that if the gas flows over that, something of that temperature with air, it will ignite. You don't have to have a pilot light.
Our stoves usually use a different type of ignitor called a piezoelectric ignitor. But we use either hot surface or piezoelectric. There are millions of hot surface ignitors out there, and all you do is when my furnace calls to -- my thermostat says, turn furnace on, first the fan will come on, it will clear out, make sure there's no residual gas that would explode, okay. And then it will turn on the hot surface ignitor. And it will start to glow hotter than my toaster oven, okay. And it won't burn up in the air because it's made of ceramic. So I can go to very high temperatures without destroying it. Most metals would oxidize away in a

few -- it would be like having a light bulb filament in the open air, it would just pop right away.

But these things were developed about 20, 25 years ago. And now you'll have another valve that turns on after a couple of seconds that will introduce the gas. And as the gas flows over this hot surface ignitor, it's just like the pilot light, it turns on.

Q. And, sir, so let me ask you this: Is the scientific concept that when the gas passes by the hot surface ignitor, which is at a several thousand degrees temperature, that the gas ignites?

A. Right. You can go to the NFPA handbook and it will tell you for different types of gases what temperature you have to be at. I've been using the U.S. Bureaus of Mines publication for that. They did a more extensive study.

Q. Sir, in terms of your opinion in this case, can you tell me what effect the thickness of the TracPipe had on its ability to sustain the energy from the lightning?

A. I'm not sure I followed that question. If you can reask it.

Q. In terms of the TracPipe, can you tell me what effect the thickness of the TracPipe had on its ability to sustain the energy from the lightning?

MR. CONROY: Judge, that again is calling --

THE COURT: I'm going to overrule it. Please,

you're trying to draw too fine a line here.

A. It took about 2.4 coulombs to blow a hole and have molten metal around the edge. Even if it's not very much molten metal, you have molten metal at about 2,500 degrees Fahrenheit around that hole.

Q. And, sir, do you have an opinion what the first fuel ignited was?

A. It was the propane gas coming out of that hole. You got the ignition from the molten metal around the edge of the hole, and you have the mixing with the air. Because of the sheer when you're going from zero velocity to a higher velocity, you get turbulence at the edge of that hole as shown by Dr. Kytomaa's photographs.

Q. And do you have an opinion from a metallurgist's standpoint as to how much energy is needed to breach the TracPipe based on the formulas that you've applied?

A. Each one of the holes took about 2.4 coulombs. To give you an example to compare that, if you just shorted out your wall plug, you'd have about three coulombs. So the amount of energy is similar to shorting out. But we have all these metallurgical features that said this all occurred within a millisecond or less, so it can't be the circuit breaker.

Q. And do you have an opinion as to whether the two holes found in the Kostecki CSST were caused by lightning?

A. Yes, I do.

Q. And what is that opinion?
A. For those metallurgical reasons I enumerated; the spatter, the sharp edges, the fact there's two holes next to each other, and the spatter -- oh, and the -- what was the other one? I can't remember. I had four before. I can't remember the fourth one.
Q. And, sir, in terms of bonding, do you have an opinion as to whether a single point bond would be effective in protecting metal of the same thickness as TracPipe?
A. If it's within 10 feet on either side, yes, it will. But if it's 30 feet away, it's not going to work. You'll get arcs to it. And an arc is going to blow a hole in this stuff.
MR. UTKE: And, sir, that's all the questions I have for you subject to cross-examination.
THE COURT: All right. So I assume that you would like to do your cross-examination tomorrow?
MR. CONROY: I think given the hour, Judge, it makes sense.
THE COURT: All right. So at this time we are going to adjourn for the evening. And I will remind you of the instructions that I have given you earlier, that during this recess, and especially as we adjourn for the evening, you're not to discuss this case among yourselves or with anyone else, including your family and friends. Do not allow anyone

to discuss the case with you or within your hearing.

"Do not discuss" also means do not e-mail, send text messages, blog, or engage in any other form of written, oral, or electronic communication as I have instructed you before.

Do not conduct any Internet research or consult with any other sources about this case, the people involved in the case, or its general subject matter. You must keep an open mind that is free of outside information. Only in this way will you be able to decide the case fairly based solely on the evidence and on my instructions on the law. If you decide this case on anything else, you will have done an injustice. It is very important that you follow these instructions.

Now, I have another matter in court tomorrow at 8:30, so we are going to resume testimony in this case at about 9:15 tomorrow rather than nine. And my hope is that we will have solved our technology problems and we will be back -- we will still remain in this courtroom. But do just return to the jury room, and if for -- if we've been unable to get the technology to where it should be, then we will have someone there to instruct you about another courtroom. And then we'll probably have a little bit of a delay because you can see the volume of stuff we would have to move to move to another courtroom, which is why we hope to avoid having to do that.

So I thank you again for all of your patience today. I apologize for the problems. I'm sorry. I've had many trials during the past six months and have not encountered these problems until, you know, just very recently in this case. So I do apologize for them. We had tested the system. We were not having problems before we started the trial. And we are doing our level best to try and correct them for you and not keep you waiting.

So we will now adjourn for the evening.

(Court in recess.)

(The following proceedings are an excerpt of the jury trial held in open court on July 10, 2013 at 9:23 a.m.:)

THE COURT: All right. Please be seated. We're going to bring your notepads right out to you. And I apologize, we're running a little late. I had to take a guilty plea in a criminal case and the defendant was running a little late, and we couldn't do anything without him. So I apologize.

But in the meantime, I want you to know Adam was wonderful, he was here at seven o'clock this morning working on our technology, and so far it looks like it's working. So we'll all keep our fingers crossed that it will continue in that manner. But hopefully we will not have the kind of

technology problems we had yesterday.

Everybody doing okay? Everybody, you're able to see everything that's being presented when the technology is working? And it does seem like the temperature is a little bit better in here now. Are you all okay with the temperature? All right. Great. Thank you.

Are the parties ready to resume?

MR. UTKE: Yes, Your Honor.

MR. CONROY: Yes.

THE COURT: I believe we were going to have cross-examination of Dr. Eagar. All right.

Thank you, sir. And you understand you're still under oath?

THE WITNESS: Yes, Your Honor.

THE COURT: All right. You may proceed.

MR. CONROY: Good morning, Your Honor.

CROSS-EXAMINATION

BY MR. CONROY:

Q. Dr. Eagar, good morning.

A. Good morning.

Q. Am I correct, Dr. Eagar, that you do not know what the peek current was of the lightning strike that impacted the Kostecki home?

A. I know what it was that caused the holes, but I don't know what hit the tree.

Q. Okay. My question is, just so we're clear, that you do not know what the peek current was of the lightning strike that struck the Kostecki home, true?
A. That's not correct. It's 2.4 coulombs per hole.
Q. Page 20 of your deposition in this matter, on July 2nd you were asked the following question:
"What was the peek current of the strike that you believe impacted the Kostecki home?"
"ANSWER: I don't know. I think Dr. Stringfellow has taken a position on which strike from the STRIKEnet report impacted the home. I haven't paid a lot of attention to that."
That's what you said, right?
A. Right. That's what hit the tree basically, and that's what we were talking about then.
Q. That was your answer, right?
A. And that's what I've said here. I don't know what hit the tree. I can tell you what hit the CSST.
Q. Now, the holes in the CSST were produced by arcing, you told us yesterday?
A. Correct.
Q. An arcing event?
A. Correct.
Q. And arcing is the only way that you can melt the metal?
A. No, lasers and electron beams can do it.

Q. Well, there wasn't electron beams here. We know there's an arcing event, right?
A. And there were no high power lasers, which is why I know it's an arc.
Q. And the question that I think you said yesterday is whether the arcing was from the line power of the house or was it from arcing from lightning?
A. Well, that's not my question. That's the question that the two sides are arguing. But I definitely concluded from metallurgical evidence that it was a lightning strike that caused these holes.
Q. Dr. Eagar, we know what you concluded. I'm trying to frame the issue. The question is whether or not the -- the question is whether or not the arcing was from the line power of the house or the arcing from lightning?
A. That's what the two sides are arguing, yes, sir.
Q. And you told us yesterday that in your opinion it took 2.4 coulombs was required to cause the size of the holes we're dealing with?
A. Each hole, so 4.8 total.
Q. And this was based on a calculation that you had mentioned back from Hagenguth's work back in 1942?
A. It's based on Hagenguth, but we did the calculation.
Q. And it's true that you can get a hole of the same size that exists in the Kostecki CSST from household current

arcing, true?
A. That's correct. I said that yesterday.
Q. And it's also true that you can get two holes in the Kostecki CSST from household current arcing, true?
A. No, you can't. You can only trip the circuit breaker once.
Q. The physical characteristics of the Kostecki CSST that you rely upon, as I understand, to conclude that it was from lightning current, one thing you identified was the sharp edges of the hole?
A. Right.
Q. And that had to deal with the duration of the current?
A. Yes, it was less than a millisecond, correct.
Q. And the other thing you pointed to was the severe spatter. I think you showed us a photograph of that?
A. That's one of the other things, yes.
Q. And that deals with the magnitude of the current, right?
A. That's correct.
Q. Now, you told us there was an inspection of the Kostecki CSST that was conducted at Exponent in October 2011?
A. Yes.
Q. And Exponent is the company where Omega Flex's, one of Omega Flex's experts, Dr. Harri Kytomaa, where he works out of?

A. Yes.
Q. And who attended that inspection from your office?
A. I did, and Mr. Mikal Balmforth attended most of it.
Q. And there was also in connection with that inspection, I think you told us yesterday that the scanning electron microscope was used, the SEM?
A. Correct.
Q. And there was another examination called the EDS?
A. That's part of the SEM, yes. It's an attachment to the SEM.
Q. And what's that called?
A. It's Energy Dispersive Spectroscopy. You essentially take the x-rays off the sample and analyze those for chemical composition.
Q. And is it true that in the same area where the CSST was located in the Kostecki home, in the area of origin, that there were also electrical conductors such as wires?
A. Yes.
Q. And you told us yesterday that you had been working in the area of arc physics for how many years?
A. 30, 35 -- 35 I guess now.
Q. Before you reached your opinions in this case, how much time did you spend personally looking at the wires that were in that area of origin, you personally looking at them?
A. I didn't do that, that was Mr. Juergens did that work.

Q. Now, it's also true, isn't it, Dr. Eagar, that when you reached your opinions in this case, you were unaware that there was an aluminum feeder wire that was in the area of origin along with the CSST and other wires, true?

A. No, I don't think that's true.

Q. All right. Do you recall this issuing coming up in your deposition?

A. Yes, I do, very clearly.

Q. And do you recall you were asked a question at page 25, line 2:

"Do you know what the circuit breaker rating was that was on the aluminum wire that was recovered from the vicinity of the hole in the CSST?"

And your answer was: "I'm not sure if it was aluminum wire. I see copper wiring in the house."

Then you go on and you continue: "That's the confusion I'm having. Conduit is different than wiring. Conduit is aluminum tube that we put wires through."

Then you were asked the question: "Well, which was there, aluminum conduit or aluminum wiring?"

"ANSWER: It's my understanding there was some aluminum conduit between two panels in that area, but the arcing that I see, two wires in the photographs is between copper wires. So the wiring in general in a house nowadays would not be aluminum. Most areas outlawed aluminum wiring

within homes."

Then you continue. "I am looking at Figures 19 and 20 of the Kytomaa report. These look like copper wires to me in Figures 19 and 20, which is what I would expect to have in a home. Aluminum wiring in a home can cause fires for different reasons."

That was your testimony?

A. Yes, sir. And that's right.

Q. And the fact is, when you gave your deposition, and that was after you had issued two reports, you weren't aware at that point in your testimony in the deposition that there was an aluminum feeder wire in that area of origin, right?

A. No, sir, that's not true. Keep reading.

Q. Right. And we do. So let's go on then. Page 26.

A. You got to get to page 30, but go ahead.

Q. We will. Okay. Page 26, it continues:

"QUESTION: Would a circuit breaker rating have any significance to an opinion of yours regarding whether full current played a role in the holes?"

"ANSWER: No."

"You have done tests at both 20 amp and 50 amp circuit breakers, and we find that both of them would trip in sufficient time, then we would get a different looking hole than we have at the Kostecki residence in the CSST."

And you say: "By the way, apparently on page 38 of

the Kytomaa report, Figure 21 does show -- does show some aluminum wiring apparently on the subfeed wiring, not just conduit."

"Okay. So there is a subfeed wiring, but I would expect -- but I wouldn't note if that was in the aluminum conduit or not, but I would expect it to be there."

Until you looked at further photographs as you got further in your deposition, you didn't even know that there was aluminum wiring in that area, did you?

A. No, sir. But I'd be happy to explain if you'd like. A circuit breaker protects the copper wiring. A circuit breaker does not protect the feeder line.

Q. That's not my question.

A. But that was what I was asked in my deposition. You go back to the very first line, the very first question you asked when you started reading my deposition, and Lynne O'Brien asked me about the circuit breakers. And the circuit breakers protect copper wiring, and that's what I was answering. Now you're switching it over to the feeder line, which is not considered that -- the wiring in the house. The wiring in the house through the outlet plugs is all copper by code.

Q. You never looked at the feeder wire yourself, did you, before you formed your opinions in this case?

A. My opinion had to do with those holes. About the

wiring, that's Mr. Juergens, and he testified yesterday. I don't have any of this in my report.
Q. The answer is, Dr. Eagar, you did not look at the branch circuit wiring to see what evidence, if any, there was of arcing, true?
A. That's correct, it wasn't part of my charge. That was Mr. Juergens who did that.
Q. You did not look at the aluminum subfeeder wire to see what evidence there was of arcing or damage, true?
A. That's correct. I looked at the holes in the CSST, that's what I looked at.
Q. And you've been studying arc physics for how many years?
A. Thirty-five years.
Q. And it's also true, isn't it, that at the time you formed your opinions in this case, you did not know whether there were any materials that were not germane or in CSST steel that were present in the area of these two holes, right?
A. I'm not sure I understand the question.
THE COURT: I don't understand your question either. If you can rephrase it.
Q. All right. Were there any materials that are not germane to 304 stainless steel that were present in the area of the two holes in the Kostecki CSST?

A. You mean on the EDS analysis, yes, there were things other than iron, nickel, and chrome.

Q. There was aluminum there, true?

A. There was aluminum, silicon, maybe some copper, calcium, sulfer, oxygen. I'd have to look at it again to remember all of them.

Q. And it's true that the presence of aluminum on the CSST in the hole areas suggests that it most likely got there from arcing from another aluminum electrode, true?

A. I said I wasn't sure in my deposition. Aluminum also shows up in dirt. Aluminum is the fifth most abundant element in the earth's crust. So if the thing is dirty after a fire, you find aluminum quite commonly.

Q. Page 18 of your deposition, line 21:

"QUESTION: Is the presence of aluminum or some other metal that might be there significant to your findings as they relate to this case?

"ANSWER: The presence of aluminum suggests that the other electrode other than the stainless steel or the CSST was most probably the aluminum because it would have transferred across the arc."

That was your testimony, true?

A. That was a possibility. If you go on later, I think it's around page 28 or 29, we discuss that in more detail. And I told you I wasn't sure. It's a small aluminum peek.

If it was definitely arcing with aluminum, you'd have a very strong aluminum peek. There is aluminum there, but I can't tell you whether it's dirt or whether it's arcing to aluminum. But I accept the fact it could be arcing to aluminum.

MR. CONROY: That's all I have. Thank you.

THE COURT: Redirect.

MR. UTKE: Thank you, Your Honor.

REDIRECT EXAMINATION

BY MR. UTKE:

Q. Good morning, sir. You were asked some questions about the two holes in the CSST?

A. Right.

Q. And Mr. Conroy asked you whether those were caused by household electric current. And can you provide me with your response?

A. In arc physics it's well known that high pressure arcs cannot operate in parallel, okay. Meaning you can't have two arcs coming from the same electrode hitting two spots on the CSST. That's a fundamental principle of high pressure arcs. They don't operate in parallel.

If I burn two holes, then I had to have had two arcs. Now, if it was household current, the circuit breaker would have tripped after the first one. So one hole could maybe, if I didn't have these other metallurgical features I

talked about, maybe that could be from household current. But the other one would have to come from something that had two arcs. And I talked yesterday about lightning flashes or many times, I don't remember if it's one third of the time or 50 percent of the time, lightning flashes have multiple flashes. I talked about it kind of -- you see it kind of flicker at you, that's actually multiple flashes that you can't distinguish because of all the bright light, they kind of overlap on your eyes.

Q. So you would expect the lightning to cause two holes during a multiple stroke event?

A. Yes. I've seen this many times.

Q. And why is it that that would not occur with household current?

A. Because household current, you can only form one arc at a time. And that one arc trips the circuit breaker, and there's no power to run the second arc.

Q. So the existence of two holes further supports your opinion that these were definitively caused by lightning energy?

A. Yes, that was one of my four points yesterday.

Q. Now, with respect to the scope of your assignment in this matter, you were asked some questions as to whether you reviewed or looked at the aluminum wiring and the copper wiring. Were you present when Mr. Juergens testified

yesterday about his examination?
A. Yes, I was.
Q. And did that happen in St. Louis?
A. What, his testimony yesterday? I'm sorry. Did the inspection happen in St. Louis?
Q. Yes.
A. It's my understanding the inspection of all that wiring took place somewhere out here in Missouri. The inspection in Natick, Massachusetts that I was present for only had the CSST. They didn't ship the other parts.
Q. So is it a fair statement that your assignment in this case was to look at the CSST; Mr. Juergens was going to look at the wiring?
A. Yes, exactly.
Q. And just as you wouldn't expect Mr. Juergens to give opinions on the CSST, you weren't asked to give opinions on the wiring?
A. That's right. Yesterday he kept on saying, well, we sent it to a metallurgist, Dr. Eagar, to look at the holes. And that's what I did. And I left it to him to worry about the house wiring and eliminating that. I didn't get into that. It's not part of my report.
Q. And you were also asked some questions about the energy necessary to cause the breach in the wall of the stainless steel for the track light?

A. Right.
Q. And the number of coulombs, is it 2.4?
A. 2.4 per hole. Both holes are approximately the same size. And if you go through the Hagenguth equation, for steel of this thickness it comes out to 2.4 coulombs.
Q. Are you able to reverse the calculation to tell how thick the metal had to be to withstand that current?
A. Yes, you can do that.
Q. And is that a scientific principle once again?
A. It's a scientific principle, but there's actually been an experiment at University of Florida that actually tested it with a real lightning strike.
Q. Well, as it applies to the TracPipe in this matter and the amount of energy that we're dealing with, are you able to calculate how thick the TracPipe would have to be to not perforate or breach when exposed to this energy?
A. Yes.
Q. And what is that calculation?
A. It's about .030 of an inch, about three times the thickness of the CSST.
Q. And earlier you stated that the CSST was about four sheets of paper thick?
A. Right. You need 12 sheets of paper to prevent this thing from perforating in a lightning strike.
MR. UTKE: Sir, that's all the questions I have.

THE COURT: Anything further?

MR. CONROY: Briefly.

RECROSS-EXAMINATION

BY MR. CONROY:

Q. So you rely on Dr. Juergens, correct?

A. For elimination of -- or placing the origin at this general area in the house.

Q. And he relies on you, right?

A. Well, you have to ask him that question, but I think he probably does.

Q. Well, you were here yesterday when he testified, correct?

A. He said that he had sent it -- suggested it go to a metallurgist. I don't remember that he drew a conclusion about the holes and lightning.

Q. But he relied upon your work?

A. I believe he is, yes.

Q. And if one of you guys is wrong in your assumptions or analysis, there's a problem here, right?

A. I guess that's a fair statement.

MR. CONROY: That's all I have, Judge. Thank you.

MR. UTKE: Nothing further.

THE COURT: May this witness be excused?

MR. UTKE: Yes.

THE COURT: May the witness be excused?

MR. CONROY: Yes, ma'am. Thank you.

THE COURT: You may be excused, sir. Thank you.

THE WITNESS: Thank you, Your Honor.

(Witness excused.)

C E R T I F I C A T E

I, Susan R. Moran, Registered Merit Reporter, in and for the United States District Court for the Eastern District of Missouri, do hereby certify that I was present at and reported in machine shorthand the proceedings in the above-mentioned court; and that the foregoing transcript is a true, correct, and complete transcript of my stenographic notes.

I further certify that I am not attorney for, nor employed by, nor related to any of the parties or attorneys in this action, nor financially interested in the action.

I further certify that this transcript contains pages 1 - 69 and that this reporter takes no responsibility for missing or damaged pages of this transcript when same transcript is copied by any party other than this reporter.

IN WITNESS WHEREOF, I have hereunto set my hand at St. Louis, Missouri, this 13th day of August, 2013.

/s/ Susan R. Moran
Registered Merit Reporter